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THE
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THE MECHANICS OF HEREDITY

By Charles Dallas Blachly

Men's most productive scientific theories are arrived at through deductions. In considering the following theory we ask you to judge it, first, by its consistency with the biological observations herein given, and, second, by those of the general trends of the modern theories of chemistry.

We shall endeavor to explain a chemical mechanism that will account for the hereditary phenomena in which offspring of the higher animals, barring dominant characteristics, resemble both parents.

We shall also describe a chemical mechanism that will account for the arrangement of the cells of the higher animals and plants. In our theory, the determinants, in a large measure, are chemical structures that are outgrowths from the two portions of a right and left handed bilateral molecule contained in the ovum. Certain peculiar behavior of protoplasm, unexplained by other theories, led to this conception. The behavior of certain optically active organic molecules have also offered more or less support to the theory. This latter we shall only touch upon in this article.

In older theories of heredity it is generally assumed that in the process of cell division of multicellular animals, bundles of determinants are passed on from cell to cell which decide the position arrangement and characteristics of the cells springing from them.

These theories have been very unsatisfactory; so much so that as late as 1928 we find Cowdrey (1) stating that, "The ultimate aim of the cytologists is to discover the principle which causes the cell to be simultaneously an individual and also one of the building stones of the organism."

Our theory describes a mechanism in which the determinants act largely independently of the nuclear contents of all the cells except those formed in the first few divisions of the ovum. This theory is consistent with the behavior of protoplasm and explains phenomena which, without it, are extremely baffling.

The following phenomena are explained more satisfactorily by this theory than by others:

1. The resemblance of the child to both parents.
2. The cause of the bilateral symmetrical arrangement of the bodies of man and animals and the cause of orderly cell differentiation as the ovum or zygote divides into many cells.
3. The mechanism of mutation, dominant characteristics and the atrophy of useless organs in the evolutionary process.
4. Why a severed earthworm will rebuild into two worms, the head end growing a tail and the tail end growing a head. (2)
5. The mechanism giving rise to homologous twins with normally placed viscera.
6. Siamese twins with normally placed viscera. (3).
7. The mechanism by which offspring have two heads and one body; two bodies and one head, and extra arms, fingers or toes in normal position. (4).

8. 'Why epithelium will become de-differentiated and assume the embryonic cell type when grown in certain artificial media. (5)

9. Why certain individuals are born with transposed viscera.

10. Why twins are born, one with transposed viscera.

11. Why, in certain cases of double monsters, one has transposed viscera.

12. Why some of the snails in a certain island have shells that are coiled clockwise in direction and others are coiled counter-clockwise.

13. Why, in certain cases in offspring with one head and two bodies, one of the bodies may have transposed viscera.

14. Why, in a certain case reported by Ziegler, two hands grew out of a single wrist, the fingers of one hand being in mirror arrangement to those of the other. (6).

15. The mechanism that may be responsible for malignant and non-malignant tumors.

16. Why laevo-glucose, which is supposed to be a mirror image in space arrangement to dextra-glucose, cannot be assimilated by the higher animals.

17. The mechanism by which certain hormones act.

18. The influence of the stock upon the offspring of the scion in plant grafting (7).

19. The mechanism by which we may possibly get an inheritance of acquired immunity, and the possible mechanism by which the apparent inheritance of acquired defective lenses of the eyes was produced in rabbits by Guyer and Smith. (8).

Morgan and others have shown some connection between the chromatin threads of the father and mother, but they have not described the chemical mechanism which causes the biparental resemblance. Weismann developed an elaborate theory in which he assumed that bundles of determinants were passed from nuclei to nuclei in the process of cell division, one determinant placing a certain cell in its proper position on the right side of the body and a corresponding determinant placing a corresponding cell on the left side, but no mechanism is given which accounts for the proper placing of the cells. In fact none of the older give reasonably clear connected steps in the process of fertilization and the later development of the multi-cellular animals.

The biological mechanism has been considered so occult that some observers have attempted to read into the life process a factor called "vital force." This, instead of clarifying the issue, only complicates it. The question at once arises as to how and on what does this vital force operate? Lull, (9) after discussing Woodruff's definition of vitalism, remarked: "Probably no biologist today accepts vitalism in its mystical and hyper-mechanical form, and yet it seems well nigh impossible to find an adequate explanation of the mysteries of life in terms of physics and chemistry."

In such a dilemma, are we not justified in concluding that our conception of the behavior of the atoms and molecules has become dogmatically narrowed, rather than that the phenomena in biology are not governed by physical and chemical laws?

By enlarging our conception of the arrangement and behavior of atoms and molecules in the light of modern chemistry and physics, the above phenomena can be accounted for. We are entitled to do this since all our knowledge of atoms and molecules depends upon deductions made from the behavior of grosser matter. Logically, we must broaden our conception to include these further facts if we find phenomena in living matter that tell us more of atomic behavior.

We cite the following quotations as showing the general trend of the conceptions of modern chemistry:

a. Mellor (10) on the Nature of Atoms.

"Chemically the atoms may be like unto the heavenly bodies, the stars, the suns, the planets, satellites, etc. The building up of the molecules is then conceived to resemble the building up of systems, such as the solar systems, or that of twin stars, or constellations, from individual bodies. This is not a simple play of words in modern chemistry or a mere analogy, but a reality which directs the course of all chemical analysis and synthesis."

b. Mellor (11) on Selective Chemical Affinity.

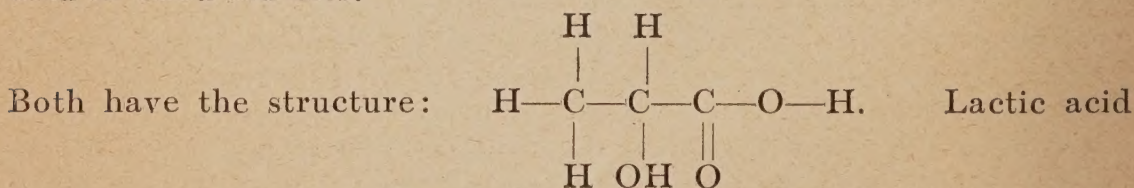
"It is supposed when two molecules meet they can react chemically only when the motions of the atoms of one molecule can be co-mingled with the motions of the atoms of the other molecule, so that instead of shattering, confounding and dispersing one another's motions, they move in a cadence and form harmonious working systems called molecules."

c. Mellor (12) on the size of ordinary molecules, such as carbon dioxide.

"If all the molecules in a cubic inch of gas were laid in a row touching one another, although they are inconceivably small, yet they are so numerous that they would form a line five million miles long. Only about one-three-thousandths of the volume of gas is actually occupied by matter, the rest being intramolecular space."

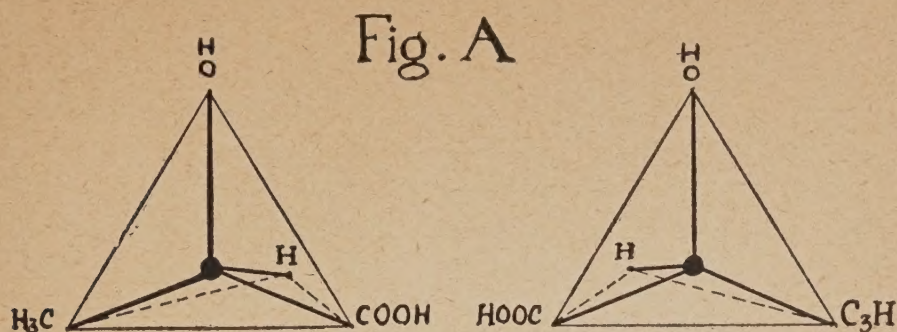
d. Steiglitz (13), on the Polarity of Lactic acid.

"We sometimes find that two or even more substances have the same structure, but are of quite different chemical identity. As an illustration, the existence of two lactic acids was observed, one in soured milk, and a different acid, sarcolactic acid in tired muscles.



Sarcolactic acid melts at 26°. Sarcolactic acid turns the plane of polarized light to the right, ordinary lactic acid has no effect upon it. Ordinary lactic acid has been resolved further into two acids: the one is identical with sarcolactic acid and the other is so much like it (it also melts at 26°) that the two could easily be mistaken for each other, like twins. These would mirror

images of each other like our right and left hands; and like these, not superimpossible, not identical. The new acid turns the plane of polarized light as much to the left as sarcolastic does to the right. We consider lactic acid, therefore to be a mixture of dextra-lactic and laevo-lactic acids." The space arrangement of these two acids is illustrated in Fig A.



THE DEVELOPMENT OF THE LIVING FORMS. The

above briefly gives some conception of the physical and chemical nature of matter as seen by modern scientists. What can the field of biology contribute to an understanding of the chemical and physical behavior of matter and, vice versa, what can modern physics and chemistry contribute to clarifying our conception of the mechanics of protoplasm?

Since we find it necessary to introduce three new terms; namely, the mirror twin molecule, the hereditary molecule and the creeping determinant, in order to explain our conception of the mechanism of heredity, it will expedite matters if we pause now and briefly describe the factors necessary for the development of protoplasm, protoplasm, as we define it, being plant and animal structures composed of atoms, the physical and chemical properties of these atoms being so arranged and so co-ordinated as to produce the phenomena of growth, reproduction, metabolism, irritability, conductivity, etc.

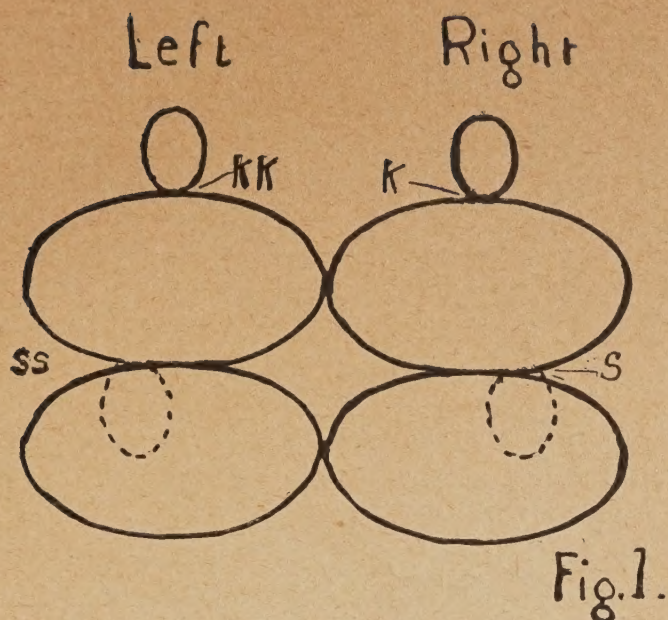
The student of modern science knows the work of the Chemberlain (14) in which he cites the occasional presence of complex organic materials in meteors and further that probably in the earlier history of the earth these meteors showered upon it in such numbers as to actually add miles to its circumference. Thus all the essential elements of protoplasm; i. e., oxygen, carbon, hydrogen, nitrogen, sulphur and phosphorous and other elements found less often, were united in vast numbers of complex molecules from pre-biological times. How did they become organized into living forms? At least six great essentials were necessary, i. e.:

(a) Numerous organic molecules of varying forms; (b) Suitable environment; (c) time; (d) heredity; (e) variation; (f) the law of the survival of the fit, meaning by the latter that

where no adequate forces are present to destroy a molecule or portion of protoplasm it will continue to exist. Any student of this subject has a pretty fair conception of the nature of the early environment, what is meant by hereditary an even of variation, though he may not put the latter so well as does Lull (15) when he says of protoplasm: "With so complex a substance the exact chemical correspondence of any two molecules is only remotely possible," however few seem to have an adequate idea of the stupendous amount of organic matter which must have been scattered through the earth's crust, nor of the amazing number of molecules contained in a cubic inch of even such an attenuated mass of gas as stated by Mellor above. Any attempt to even estimate the number of such organic molecules exposed constantly to changes due to heat, moisture, radio activity, atmosphere changes, etc., at once justifies one in assuming that almost any chemical combination could be brought about. The lapse of time seems another factor seldom comprehended by the average student. Ten thousand years seems a long while to a man who has lived fifty, yet if we let a line one inch long represent a lapse of ten thousand years it would (by using the same scale) take a line 12,500 feet long to represent a billion and a half; i. e., the estimated time which has passed since microscopic forms appeared on the earth. Probably ultra-microscopic form extended back many, many years further, yet a billion and a half years is a span long enough to cause one to marvel when he realizes that the biological tree extends back thus far.

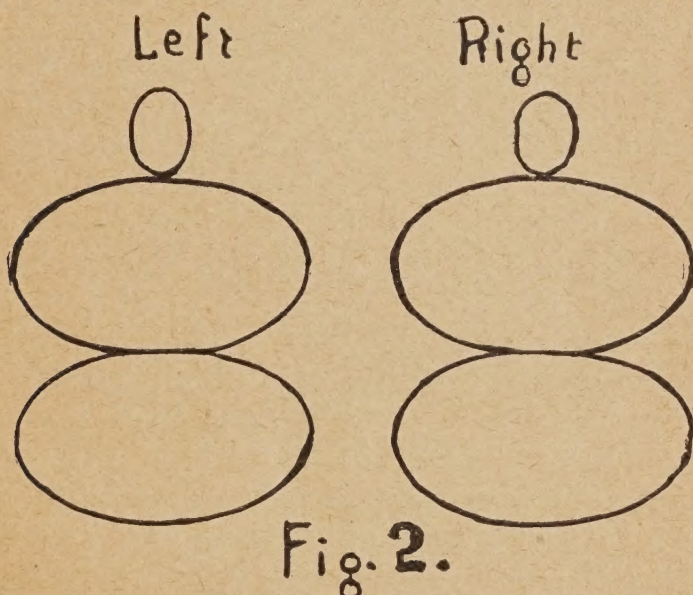
Before going to show how these factors combined to produce the living cell, the reader is invited to recall the reference previously made to the characteristics of lactic acid as described by Steiglitz, as it was from the behavior of this acid that the writer derived the idea of the mirror twin molecule. Steiglitz tells us that lactic acid, as found in sour milk, can be divided into two acids identical in structure and in melting point (26°), except that one turned the plane of polarized light to the right, the other to the left. The melting point of the original acid was 18° and polarized light was not affected by it. He speaks of lactic acid as being a mixture of dextro-lactic and laevo-lactic acid. We, however, predict that as lactic acid has a different melting point from its two component acids, that, in reality, the two components parts are probably loosely bound together by selective chemical affinity so they form a single bilateral molecule possessing mirrorlike arrangement, hence the term MIRROR TWIN MOLECULE. Our second hypothetical molecule, the HEREDITARY MOLECULE is a mirror twin molecule, characterized especially by the properties of (a) cleavage and (b) regeneration. Its existence is deducted from the behavior of grosser living forms of matter.

A. The heritary molecule is very diagrammatically illustrated in Fig. 1. Note this figure is bisymmetrical. The ellipse represents the orbits of the bodies forming the bilateral molecule.

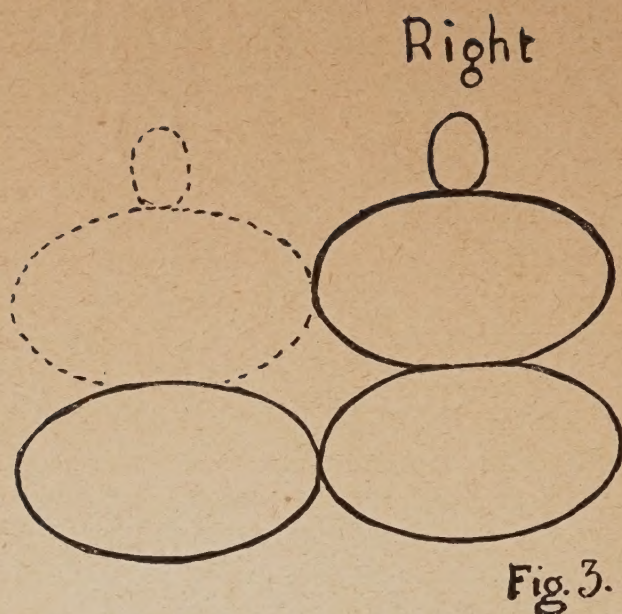


(a) CLEAVAGE. The weakest portion of this mirror twin molecule is apparently between the right and left halves, thus inviting fracture at this point.

B. By Cleavage, hereditary molecule (Fig. 1) may be separated into its right and left halves as shown in Figure 2.



(b) REGENERATION. A fractured mirror twin molecule may rebuild each or both halves, if the environment is suitable. This regeneration depends upon the selective chemical affinity, due to the arrangement of the orbital planes of the atoms or the molecules at the point where the two halves were separated. Thus two new hereditary molecules result: In Fig. 3 we see that the right half of Fig. 1 has taken up a radical in the process of regeneration illustrated by the ellipse on its left. The radicals that are still necessary to complete the bilateral molecule as in Fig. 1 are shown by the dotted ellipses.



With two of the new terms thus described, we are ready to go on to the origin of the living cell with the definition and description of the third, the CREEPING DETERMINANT, reserved until needed in discussing the multicellular organisms.

ORIGIN OF THE LIVING CELL

Living cells have the characteristics of growth, reproduction, metabolism, irritability, conductivity, etc. As these properties are all highly useful in the multiplication and existence of the cell, we shall speak of each as an advantage, growth being Advantage No. 1; reproduction, Advantage No. 2; metabolism, Advantage No. 3, etc. A brief discussion of the method by which one after another of these advantages developed in the descendants of the same hereditary molecule will be sufficient to show how, by accumulation of advantages, the living cell, as we know it, could be evolved.

Advantage No. 1—GROWTH: This advantage depends upon the arrangement of the orbital planes of the hereditary molecule as described in its rebuilding above.

Advantage No. 2—REPRODUCTION: In the numerous mirror twin organic molecules present, possessing advantage No. 1, some would, through variation, possess openings where radicals could attach in such a way, that through their motions or other properties, they would break the molecule apart into its right and left halves, each half then would rebuild to a point where, through selective chemical affinity, it would take up a like radical and so be broken apart and so on and on, each rebuilding to the point where similar radicals would be attached, breaking the molecule asunder, so in time literally myriads of these molecules, each possessing both advantages, i. e., Advantage No. 1, growth, and Advantage No. 2, reproduction, would be in existence.

Advantage No. 3—METABOLISM: In the myriads of hereditary molecules possessing both advantages No. 1 and No. 2, some would, by chance, vary so as to take up radicals that would have the property of synthesising certain chemical bodies from

the elements surrounding them, into other chemical bodies useful in rebuilding the hereditary molecule, thus making possible more frequent and therefore more numerous progeny, due to the possession of advantages 1, 2 and 3. Thus, through variation, certain fortunate hereditary molecules accumulated advantage after advantage, useful in their multiplication and existence, e. g., cilia, cell walls, the mechanism for fertilization, etc., finally resulted, so that now after a billion and a half years these advantages are innumerable.

THE CREEPING DETERMINANT

Disregarding fertilization for the time being, the reader's attention is directed to the earlier cell forms which undoubtedly, at first, were ultra-microscopic; later they became more complex and larger.

In the process of cell division, some varied so as to split entirely apart, others only partly. These last were the beginning of the cell colony. Variation went on, determining which colonies were to exist and which to perish. Literally myriads of groups were tried out. Through variation in some colonies, the hereditary molecules in any single cell of the colony could so grow by taking on radicals until they passed out through their own cell wall and invaded the adjacent cells. Co-mingling with the planetary planes of the atoms there, chemical changes were brought about that caused differentiation in the invaded cells. Still through the process of variation mechanisms were developed in the colonies that prevented the growth of any hereditary molecule beyond its own cell wall, except usually the mirrorly arranged lateral halves of the hereditary molecule originally belonging to the mother cell of the colony. These would organize the colony into bilateral structures of differentiated cells, known to exist in the earlier animals. These prolongations of the hereditary molecule were the beginning of the structures that largely determine the differentiation of the cell types seen in the higher organisms today. Now they ramify through the bodies of the higher organisms, determining the character of the cell in any given part; thus the positions of the orbital planes of our right and left mirrorly-placed little fingers, respectively, were determined by the orbital places in the right and left halves of the mirrorly-arranged hereditary molecule of the zygote from which we sprung. This vast prolongation of the orbital planes of atoms may be crudely compared to a prolonged structure of nested cups of definite shape. Of course, in complex organisms these "nested" orbital planes take on the nature of a reticulum due to the arrangement of the orbital planes of the electrons about their protons in the atoms. As will be shown later, the ability of the creeping determinant to take up radicals of certain chemical nature at a given place, probably depends upon a slow deviation in space between certain lines of orbital planes as the structure spreads. When this deviation reaches certain proportions new radicals can find attachment in these openings. These two structures just mentioned, which grow out of the right and left halves of the hereditary molecule, organizing adjacent cells into definite

bilateral forms, we shall designate the CREEPING DETERMINANTS. This conception of creeping determinants answers Cowdrey's question as to why a cell is simultaneously an individual and also one of the building stones of the organism. A creeping determinant does not, as a rule, alter the hereditary molecule of an invaded cell nor its chromatin content, but its effects are largely produced in the cell cytoplasm.

Consider now the ovum of some of the higher animals as it divides and subdivides into a mass of undifferentiated cells as is known to occur in the early history following fertilization and in some places where fertilization does not take place. Suppose now after this mass has reached certain proportions two reticular protoplasmic processes grow out of the right and left halves of the hereditary molecule originally belonging to the zygote (or ovum), their chemical nature being, of course, determined by the orbital planes of the parts from which they spring. Each continues to grow longer and longer, as it takes on radicals, one parallel to the other until it enters adjacent cells. The chemical arrangement of these two outgrowths would be in mirror position, but otherwise of similar chemical structure. These prolongations reorganize the cell bodies of the penetrated cells so as to form two similar mirrorly-placed differentiated cells. Extending on and on through cell after cell, they eventually would produce the arrangement of cells as seen in the higher forms. We could understand how different portions of this creeping determinant could be of different chemical structure so as to organize new cells into ectoblast, mesoblast and endoblast and hence skin, muscles, mucous membrane, etc. Later it could produce the fish-like structure so well known in the higher embryos, later still, the tadpole shape, and finally spread so as to produce the beautiful bilateral structure seen in all higher mammals.

Heitzman, as early as 1873, thought that a continuous reticular protoplasmic network extended through the body of the higher animals with the cells scattered throughout this meshwork. No mechanism was given that could account for such a reticulum determining the character of the differentiated cells. Many others have observed reticula in prepared specimens, but as most of these tissues have been hardened by fixing fluids, care should be used in interpreting them. As for the determinants failing to be seen and recognized, there is nothing strange about this. We all know how long it was before the *spirochaeta pallida* of syphilis, were recognized, although they have a structure of very definite form. Furthermore, creeping determinants may be ultra-microscopic in size.

The unique thing about this theory is that of the extreme selectivity that must be present in the hereditary molecule and its creeping determinants; however, his extreme degree of chemical selectivity is no more amazing than the life process itself, so why not broaden our conception to include it? The mirrorly-placed bilateral projections are nothing more or less than radicals with selective chemical affinity which attach themselves to the hereditary molecule. When the form of this spreading determinant reaches certain proportions, due to the direction or arrangement

of the orbital planes of the radicals, openings occur in it where still other radicals of different chemical nature may find attachment, thus giving rise to various cells. In this way we can conceive of the development of the multicellular organisms without introducing into our plan some mystical element like "Vital Force." It has taken over a billion and a half years of "Natural Selection" for the higher organisms to reach their present state of extreme complexity. We marvel at their beauty, but is it necessary for us to say that we cannot understand the mechanism by which such a structure develops?

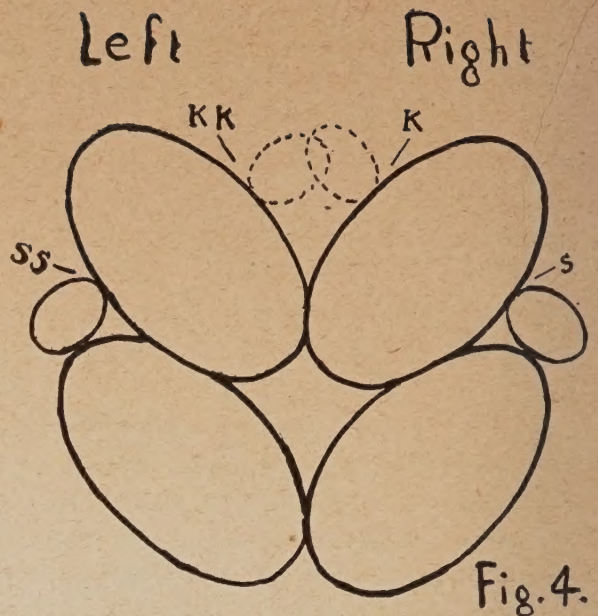
As stated earlier, there is evidence that the lateral halves of the hereditary molecules need not be exactly alike. This deduction is made from the fact that some of the organs are of asymmetrical arrangement; therefore, the creeping determinant, giving rise to them, need not be exactly symmetrical. This, however, does not preclude the possibility of molecules in mirror twinning always giving rise to practically perfect mirror twins. It is possible that the hereditary molecule is composed of submirror-twin molecules whose bilateral halves are placed to the right or left of those of the main molecule. This could give rise to asymmetrically placed organ.

-- FERTILIZATION

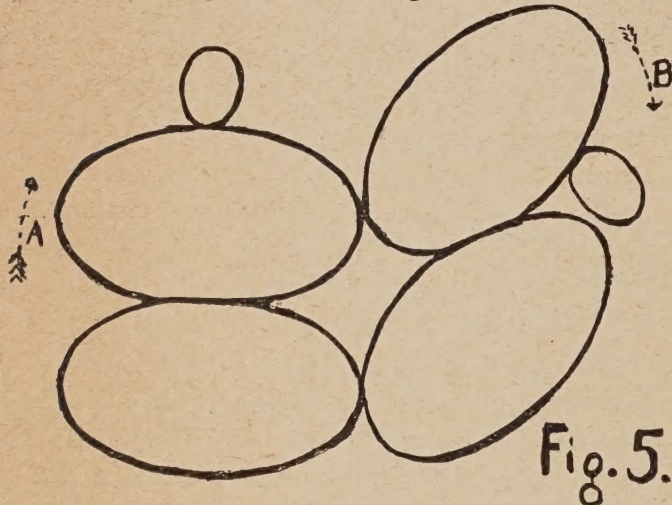
We shall now apply the theory of the hereditary molecule to the phenomenon of fertilization. In fertilization we know there must be some chemical mechanism by which the co-mingling of the sperm cell and the ovum can give rise to the offspring which possesses the mutual characteristics of the parents. We feel that in the molecule, as in the constellations of the stars, the position of the orbital planes of one atom influences the position of the orbital planes of the other. In this theory we assume that the orbital planes of the corresponding right and left halves of two hereditary molecules may be in such close harmony that they may unite chemically and still they may not be in exact harmony.

Suppose now the male hereditary mirror twin molecule breaks into its right and left halves and likewise the female hereditary mirror twin molecule breaks in a similar manner; then the right half of the male molecule will unite chemically with the left half of the female molecule, but because of the slight difference in their structure their orbital planes will not be in exact balance. Under such circumstances, when the right half of the one is united with the left half of the other the direction of the orbital planes of each system will be mutually warped until they assume a neutral or balanced position. Thus in Fig. 4 we have a second bilateral hereditary molecule different from that in Fig. 1, but so like it they can unite.

Suppose then that the right handed portions of the hereditary molecule (Fig. 4) unites with the left-handed portion of the hereditary molecule (Fig. 1), then we would have a molecule such as Fig. 5,

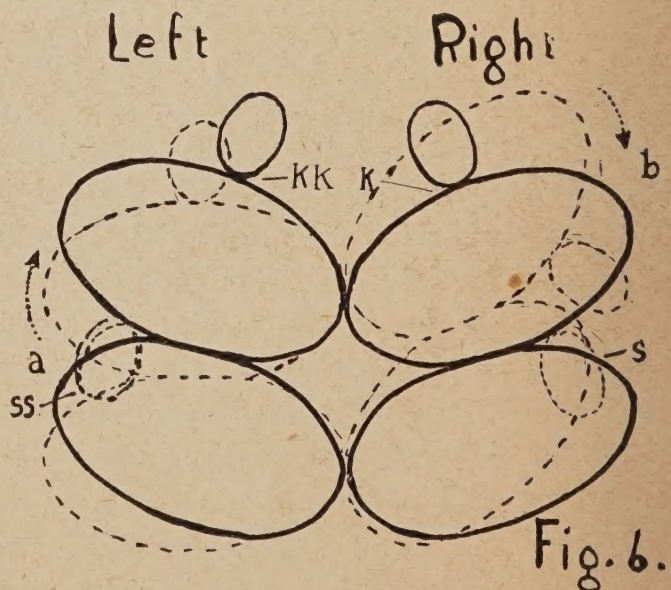


Left of Fig. 1. Right of Fig. 4.



but the planetary planes would be under strain. To bring about a balance, the left-handed portion would be warped in the direction of arrow "A" (Fig. 5) and the right-handed portion in the direction of arrow "B" until they reached the neutral position shown by the dark ellipse in Fig. 6.

Thus we would get a new form which in arrangement would be somewhat of a mean between the two original hereditary molecules (Fig. 1 and 4), whose parts entered in the union. In Fig. 6 the dark portion represents the new system resulting. The dotted ellipse in Fig. 6 represents the position the two halves were in before they mutually warped one another. From this new here-



ditary mirror twin molecule arises a creeping determinant whose actions have been described above. This will give rise to a child somewhat resembling both parents.

NOTE: Some reservations is held by the writer as to the direction from which component parts of hereditary molecules are united in fertilization; also as to the relative amount that each component part mutually warps the position of the others' orbital planes. These two factors, together with multiple twinning, may be the cause of certain combined symmetries and asymmetries seen in biology.

With the theories of the mirror twin molecule, the hereditary molecule, the acquiring of various advantages in the process of evolution, and the creeping determinant in mind we will now see how they explain the phenomena given early in this article.

1. The biparental resemblance of the child is explained by the mechanism given for fertilization and the theory of the creeping determinant. The phenomena under item 2, i. e., the cause of the bilateral arrangement of the bodies of animals and the orderly cell differentiation, are explained in the same way.

2. The mechanism bringing about mutation, dominant characteristics, and the atrophy of useless organs in the evolutionary process may be explained by a study of Figs. 1, 4 and 6 in the process of fertilization. In Fig. 1 we see small radicals, whose orbital planes are represented by the ellipses, united to the larger orbits at K and KK, respectively. In the other hereditary molecules, Fig. 4, there is no room for the attachment of these radicals at these relative positions without the two radicals interfering in their orbits. This interference is shown by the dotted ellipses at KK and K in Fig. 4. After the position of the orbital planes have been warped in the process of fertilization as shown in Fig. 6, there is still ample room for the attachment of the radical at KK and K. This radical then could give rise to a dominant characteristic handed down from hereditary molecule Fig. 1.

The reverse mechanism of this is seen in regard to the small radical SS and S in Fig. 4. Due to the positions of the larger orbital planes in Fig. 4 there is plenty of room for small radicals SS and S to attach in that position. There is no room in the relative position as shown by the dotted ellipses at SS and S in Fig. 1. After the warping of the positions of the orbital planes in the process of fertilization there is still no room for the attachment of the small radicals at position SS and S in the new hereditary molecule that resulted. By this last mechanism in the process of variation, useless organs could slowly atrophy. Somewhat the reverse of this last mechanism will account for mutations in the following way: In fertilization, where two hereditary molecules have planes that are almost separated to the point where a new radical can be taken up in a new position, a slight variation due to chance may so act as to open these orbital planes in the offspring to the place where this new radical can find attachment. This then could give offspring with different body characteristics than those of the parents. No doubt the new deviation in distance between the planes in the zygote would ordinarily not become wide enough to receive this new radical until it extended into the creeping determinants.

At this article it will be impossible to go into details of dominant and recessive characteristics, and the nature of the chromosome. As to whether each chromosome necessarily contains separate hereditary molecules or not is open to question. The chromatin thread may simply contain mirrorly arranged bilateral molecules having the property of cleavage and rebuilding as does the hereditary molecule. These bilateral molecules would multiply and be handed down from cell to cell in these respective threads and also find their way into body fluids and at certain places in the spread of the creeping determinant when openings between orbital planes become wide enough, find attachment and thus influence the direction of its spread, or, in other words, act as a hormone described later. Thus the male chromosome described by Morgan could turn the spread of the creeping determinant so as to produce the male structures. Other bilateral molecules of the chromatin could act so as to close certain openings in the creeping determinant. This will be discussed farther under hormones.

On the other, hand, however, a very beautiful scheme, consistent with the Mendelian law, can be pictured where the centrosome and also each of the chromatin threads contain one hereditary molecule. The hereditary molecule of the centrosome in this scheme would be fertilized in turn by each of the hereditary molecules in the chromatin thread in the ripened germ cell and after the zygote was formed there could again be a refertilization of each hereditary molecule of the chromatin threads of the zygote by the hereditary molecule of its centrosome.

Why will a severed earthworm rebuild into two worms; the head end growing a tail and the tail end growing a head? This is readily accounted for under this theory by the fact that in the severing of the worm, open ends of the creeping determinant were exposed in each half. These, of course, due to the arrangement of their orbital planes, could only nest radicals similar to the ones they had been nesting so that they would reorganize new cells so as to reproduce the missing parts. This would be the same as rebuilding a broken line of nested cups as mentioned above. By adding new cups to one broken end it could be rebuilt in one direction and to the other broken end in the other direction and thus produce two new lines of cups of the same length as the original. All the phenomena given in 5, 6 and 7 relative to normal Siamese twins, etc., are explained in the same way by embryonic cleavage and later rebuilding by virtue of the open ends of the creeping determinants. Partial cleavage gives rise to monsters, etc.

Why will epithelium become de-differentiated when grown on certain artificial media? This is probably due to the medium not containing proper bodies to keep that creeping determinant growing. Another possibility is that the rapid division of the epithelial cells outrun the growth of the creeping determinant so that finally the new cells contain no creeping determinants, and those having it become very scarce or perish entirely.

Why are certain individuals born with transposed viscera? This is probably due to the inherent tendency of certain organic

molecules to produce mirror twins; this mirror twinning being due to the arrangement of the orbital planes of the molecules. This mirror twinning can take place in any direction about certain optically active arranged molecules. Thus, if we were to view the hereditary molecule of the zygote from in front it could form a mirror twin either to its right or to its left. The lateral halves of the hereditary molecule of the higher animals must be slightly different in arrangement as their hearts, livers and stomach are asymmetrically arranged. Supposing while viewing a hereditary molecule from in front a mirror twin was formed to its left; then you see the new twin would be in transposed arrangement to the normal from which it sprang. If these hereditary molecules were broken they could give rise to twins, one having transposed viscera. If the normal hereditary molecule perished, for some reason, one child having transposed viscera would result. The same effect could be produced if the creeping determinant would form a mirror twin in a comparatively early stage. This last is of frequent occurrence in certain lower animals. In double monsters, where one has transposed viscera, the mirror twinning of the creeping determinant is incomplete so that there is not entire separation.

Why do some of the snails of a certain island have both clockwise and counter-clockwise coiling of their shells? This mechanism is the same as that producing transposed viscera.

Why, in the case described by Ziegler, did two hands grow out of a single wrist, the fingers of one hand being in mirror arrangement to those of the other? This is a unique example of our contention that certain organic molecules tend to form mirror twins. In this case the radical of the creeping determinant, which gave rise to the fingers, twinned. It is far fetched to attempt to explain this phenomenon on the grounds of natural selection and the survival of the fit, as some have used in explaining the bilateral development of the body, because it is difficult to see how, at any time, two hands in this position could be of use to our ancestors.

What mechanism may be responsible for malignant and non-malignant tumors? We will first illustrate this by the structure of the wart. In the skin we assume that there is a creeping determinant that arranges the cells in their respective layers, such as the basal cells, the malpighian cells and those of the corneum.

The direction of the orbital planes of the creeping determinant underlying these structures is harmonious with the creeping determinant of the epidermal layers. This harmony gives us the condition Ewing (16) and others described as tissue tension. Now, in certain warts the creeping determinant twins in such a direction as to form epithelium structures at right angles to the normal. Therefore the warty structure results. In the non-malignant wart the twinning is in such a direction and of such a character that tissue tension is not disturbed. Therefore the body is not invaded by this newly formed epithelial tissue. Due to the nature of blood vessels supplying the tissues with nourishment as described elsewhere, the blood vessels and connective tissues follow this warty

growth. It is probable that the creeping determinant of the sub-epidermal structures form mirror twins at the same time in wart growth.

In cancers it is not unlikely that mirror twinning is in such a direction as not to be harmonious with the tissue tension of the underlying structures; therefore, the cells arising from this new determinant can invade the structures of the body. The direction of the bodies in their orbits in the molecules of the creeping determinant may be a deciding factor as regards tissue tension.. What has been said of the origin of skin tumors will apply to practically any of the new growths.

Why will laevo-glucose not be assimilated by the higher animals? Is it not possible that while this substance has a spacial arrangement which would cause one to expect it to be assimilated in the same place as glucose, that in reality the direction of the atoms in the orbital planes in his molecule are such that they are not harmonious and therefore will not fit into the tissues of the higher animals. This sugar might be somewhat analogous to the one suggested in malignant tumors. If this is true, by substitution, we may be able to add poisonous radicals to laevo-glucose or other bodies of proper arrangement that will unite with and destroy these malignant tumors and still not unite with the normal tissues. Germ diseases might offer the same angle of attack.

Under this theory how do many hormones act? Hormones, such as those of the pituitary or gonads, may be bodies that find attachment in various locations in the creeping determinant and alter the nature of its spread.

How may the stock influence the offspring of the scion in plant grafting? Bilateral twin molecules from the cells of the stock capable of reproduction, after the method of the hereditary molecule, may find their way from the cells of the stock through the plant fluids to the reproductive cells of the scion and there take up a position in the chromatin threads of the germinal cells in the scion and thus influence the character of the offspring by further division, and by later attachment to the creeping determinant of the offspring.

What mechanism will explain the possible inheritance of acquired immunity and the apparent inheritance of acquired lens defects as produced in the rabbit by Guyer and Smith? No doubt in the bodies of the higher animals there is a mechanism developed by which portions of their structures, through stimulation, will multiply so as to produce specific anti-bodies to meet the invading protein poisons. It is only a step further to conceive of how some of these structures can have the bilateral twin arrangement capable of reproduction and find their way into the chromatin threads of the germ plasm and thus be transmitted.

The growth of aberrant nerves and aberrant blood vessels probably depends upon local hormones. Such anomalies as cyclops eyes, metaplasia, etc., are probably produced by reversion in type to early forms from a mechanism somewhat the reverse of that of mutation. There is probably some part of the creeping determinant that due to the position of the orbital planes, persistently tends to produce the general form of the higher animal. Probably sub-creeping determinants that are off-springs from the creeping determinants gives rise to structures as skin, nerves, and blood vessels. The growth of these latter depending largely upon local hormones which cause them to extend only when they are needed to supply parts.

Repetition of a given phenomenon is good presumptive evidence of the validity of a theory which is deduced from one case providing no inconsistencies are found. The above theory was deduced largely from phenomena observed in the higher vertebrates which number about thirty-five thousand species. In the insects which number about three hundred and sixty thousand known species, bilateral arrangement is constantly found. Plants constantly show bilateral arrangement in their leaves and symmetry in budding and the arrangement of their flowers that is readily explained on the theory of the tendency of certain organic compounds to form mirror twins.

The mechanism herein described as the one which gives us the fertilization phenomena, also explains the hereditary tendencies of these thousands of species with a clearness that no other mechanism suggested has been able to do.

We conceive of the hereditary molecule as a chemical structure that will, under favorable circumstances, by virtue of its selective chemical affinity, due to the arrangement of the orbital planes of its component parts, add radical after radical to its structure until it expands in size so as to finally organize cells so as to produce a gigantic mirror twin molecule having the arrangement and characteristics of the bodies of the higher animals and plants.

Under this theory man is not only a great swarm of electrons and protons whirling so as to form atoms and these atoms again whirling around in the form of molecules and so on, but more magnificent than this, he is, in a measure, a great mirror twin atomic constellation, the movements of all parts which are moving in harmony or cadence.

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THE MECHANICS of HEREDITY

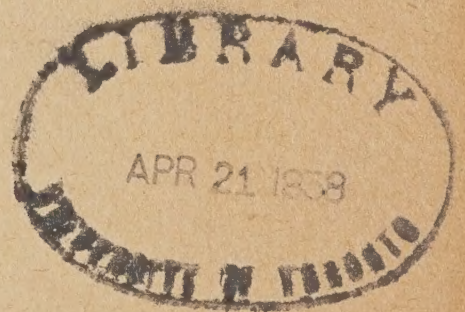
(Second Paper)

By CHARLES DALLAS BLACHLY (1878 -)

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SUPPLEMENT

THE GENE

In these papers the gene is looked upon as a minute reproducing mirror-twin molecule similar to the earlier forms of ultra-microscopic life. These genes are associated with the chromosomes during cell division.

Action of Genes

Genes produce their effect on growth either—First, by producing chemical bodies that attach to or otherwise effect the arrangement of the creeping determinate, or Second, genes in some cases may become directly attached to the creeping determinate. This second mechanism is pointed to by an experiment of Guyer and Smith. These investigators succeeded in producing the inheritance of acquired lens defects in rabbits in the following way:

Lens substance of the rabbit's eye was injected into a fowl and a specific anti-serum for rabbit's lens substance was thus produced in the blood serum of the fowl. This anti-serum then was injected into a pregnant rabbit. This serum not only injured the lenses of the injected rabbit's babies, but also the offspring of the babies had defective lenses in the same ratio as is consistent with Mendelian recessive characteristics. This experiment is at least suggestive that a considerable part of the lens and the gene producing the lens are the same chemical body as both are destroyed by the same specific anti-serum.

Origin of Genes

Some genes may originate from portions of the cell or creeping determinate becoming detached. These pieces, due to the arrangement of their fields of force, may become independent reproducing mirror-twin molecules that influence body growth. These reproducing bodies entering into the chromosomes of the germ cells may be passed from generation to generation and thus affect descendants.

Other genes may be reproducing mirror-twin bodies that originate outside the organism and obtain entrance into it in various ways. The influence of the stock upon the scion, as mentioned in the first paper is an illustration of an organism acquiring a foreign gene. It has been shown that when a white radish scion is grafted upon a red beet stock the offspring of the radish have the red color of the beet. Here possible the red producing genes of the beet root stock find their way through the plant fluids to the chromosomes of the white radish scion's germ cells and thus are passed from generation to generation giving the red color in the descendants of the radish,

Mutation of Genes

Genes may undergo mutation or variation due to the forces causing changes in arrangement of atoms in reproducing mirror-twin molecules as discussed on page 6, in the second paper.

HORMONES

Some Hormones are probably chemical bodies that directly or indirectly affects the spread of the creeping determinate. The mechanism of their actions are similar to that of the genes.

The Mechanics of Heredity

(Second Paper)

By Charles Dallas Blachly

PREFACE

This second paper embodies essentially the same hypothesis as advanced in our earlier one of May 1929, but the subject is presented somewhat differently. The earlier paper is given in full at the close of this second. Notwithstanding certain defects the first paper contains, it should be read by those interested, as it discusses phenomena not included in this second one.

THE MECHANICS OF HEREDITY (second paper)

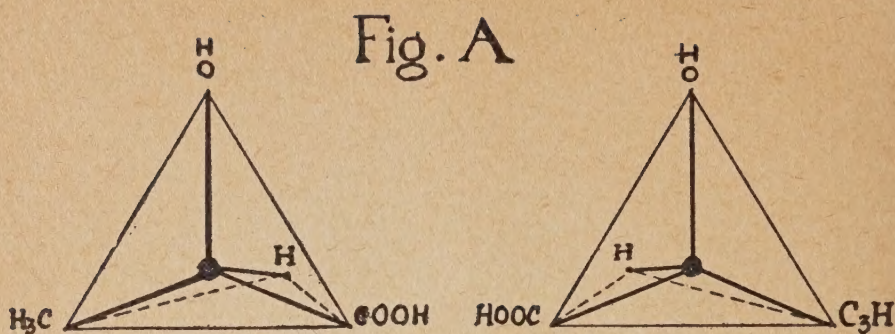
When one studies the morphology of organisms he is amazed by the persistence with which nature produces symmetrical plants and animals. In one class alone, the insects, it is estimated that there are over four hundred million forms in which bilateral arrangement, or perhaps more descriptive, the mirror-twin arrangement is perfect in practically all varieties. Comparatively perfect bilateral symmetry is found almost universally in foliage and it is common in other plant structures. The bilateral or mirror-twin structure is so common in vertebrates that asymmetrically arranged organs, such as the heart and intestinal tract, are the exceptions, not the rule. Even in these instances nature occasionally tends to complete the perfect bisymmetrical figure as is evidenced by certain Siamese-twin types in which one of the united pair has transposed viscera or is the mirror-twin of the other. Again two hands growing out of a single wrist and having mirror arrangement of their fingers, have been observed.

Is this bilateral arrangement a matter of chance, one brought about altogether by the survival of the fittest, or is the phenomena more significant, in that it beckons us to a better understanding of the behavior of electrons, atoms, and molecules in the origin and structure of protoplasm?

I am advancing an hypothesis dealing with the mechanics of heredity. This hypothesis entertains the following conceptions:

First, that protoplasm is a structure composed of atoms in which the physical, chemical, and other properties of the atoms are so arranged and so co-ordinated as to produce such phenomena as growth, reproduction, metabolism, irritability, conductivity, and so forth.

Second, that life arose out of organic molecules having a right and left handed, or mirror-twin arrangement of the two lateral halves. A molecule having bilateral arrangement similar to the combining of the molecules of dextro and levo lactic acid as shown in Fig. A. You will



observe that the groups of atoms, frequently called radicles, are attached about the central carbon atom in one order on the right side and in the reverse order on the left, so that the right and left structures hold the same relation to each other as an object holds to its image in a mirror.

(Note) In this paper we will apply the term molecule to much larger aggregates of atoms than is usually done by writers. By so doing the hypothesis is more easily set forth. One will recall that the names given the various sized groups of atoms have always been more or less arbitrary.

Third, that biological reproduction came about in somewhat the following way: In the myriads of these mirror-twin molecules that were produced thru the constant shifting of the elements in past ages, some of them were formed, which by virtue of the arrangement of the fields of forces associated with the atomic groups, would under certain conditions, break into their right and left halves. Again under certain conditions each half would take up atoms or radicles of such arrangement as to build back the same arrangement as the original. This was the beginning of reproduction. We will speak of the power of a chemical body to take up radicles only of a certain type, due to the arrangement of its field of force as "selective chemical affinity."

To these bilateral molecules having the property of division into right and left halves under certain conditions, and later under certain conditions having the property of again rebuilding into two complete bilateral molecules like the original we give the name, THE HEREDITARY MOLECULE.

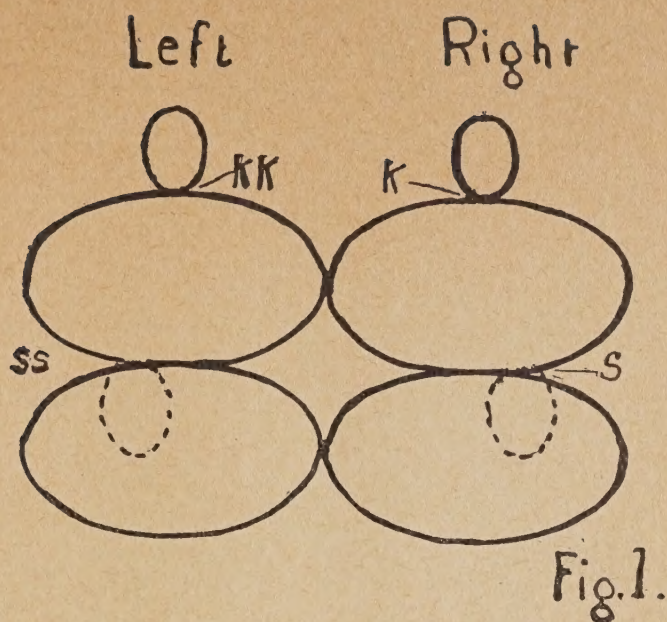
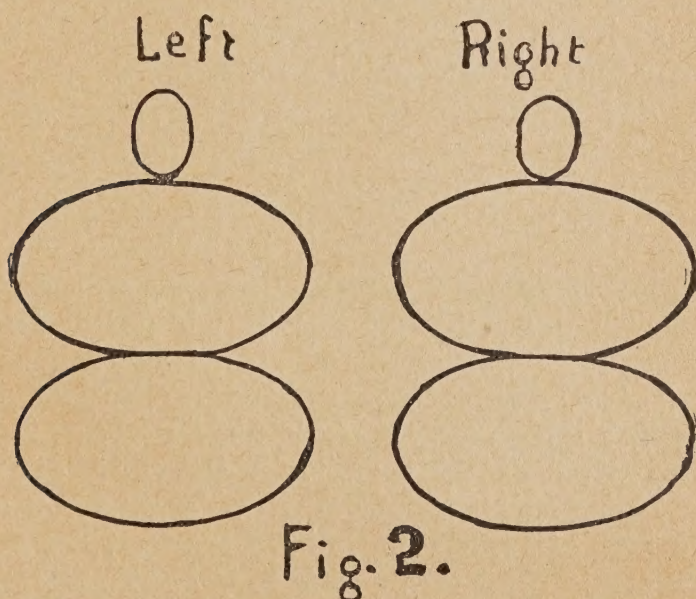
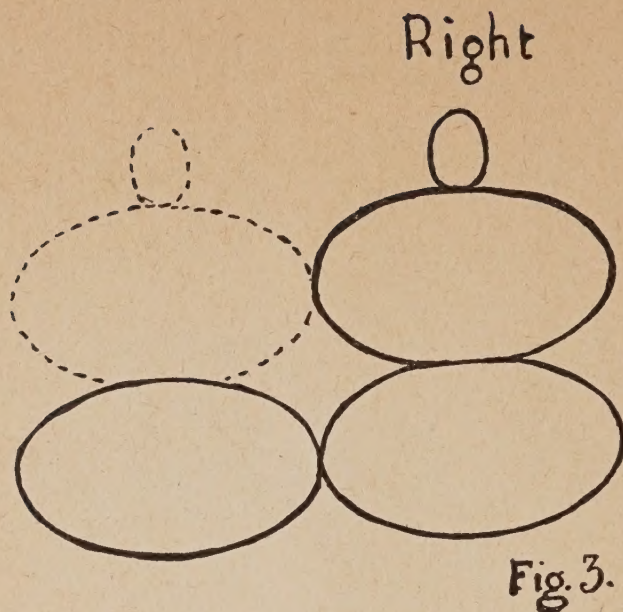


Figure 1 is a schematic illustration of this reproductive phenomenon, the complete figure illustrates the HEREDITARY MOLECLUE. The ellipses represent the fields of forces associated with the radicles or atomic groups of the hereditary molecule. Under certain conditions this Hereditary Molecule (Fig. 1) will break into its right and left halves



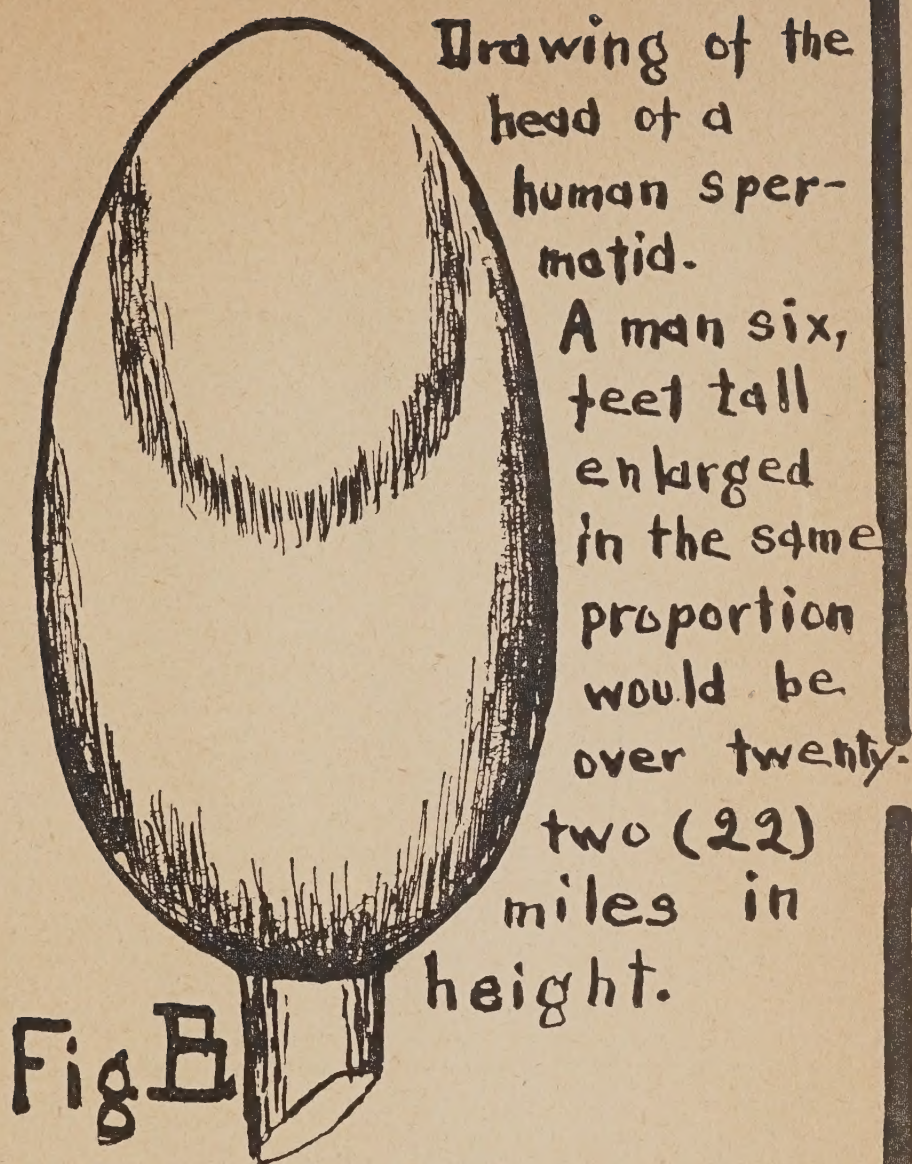
as shown in Fig. 2. Again due to selective chemical affinity, under certain conditions, each half will rebuild. Figure 3, shows the right half rebuilding. One radicle has already been taken up. The radicles still needed to complete the structure are shown in dotted ellipses.



Fourth, that due to this property of reproduction myriads of these HEREDITARY MOLECULES appeared on earth and due to the multitude of forces to which they were exposed, such forces as radio activity, isotopes, in atomic structures, changes in heat, moisture, etc., some of them varied in the arrangement of the atoms and in their fields of forces so that they took up new radicles. If a newly acquired radicle was useful in the existence and reproduction of the molecule possessing it, that particular molecule had greater numbers of off-spring. If it was markedly detrimental it or its off-spring perished. Thus certain hereditary molecules, thru natural variation added useful radicle after useful radicle to their structures until they finally assumed the complexities of the living cell.

THE CREEPING DETERMINATE

Now passing fertilization for the time, we will discuss the cell arrangement and cell differentiation of the multicellular organisms. Let us refresh our memories as to relative sizes between cells and adult organisms. Figure B is an illustration of a human spermatid enlarged until its head is four inches long. On the same scale an adult individual arising from a zygote formed by the union of this enlarged sperm with some correspondingly large ovum would be about twenty-two miles in height. Unless we consider protoplasm chaotic in structure, we know that some atomic arrangement within this sperm, in conjunction with some atomic arrangement within the ovum, predetermines the space arrangement of all parts of this twenty-two mile-high giant, as the off-spring is somewhat of a mean in space arrangement between the parents. As this giant reaches maturity we know that in the tips of the right and left little fingers, that would be about twenty-two miles apart if he held his arms outstretched, cells would be forming in practically the same



pattern, except that these patterns will hold mirror-twin relations. In the normal sized man the same relative proportions between the size of the sperm and the adult man exists.

What mechanism can be conceived of that will account for such a definite bilateral pattern being followed from the minute zygote or ovum to the adult form? In this hypothesis every cell contains at least one HEREDITARY MOLECULE to which all other cell phenomena, such as the action of the chromatin threads, are somewhat subservient. The earlier cell forms were ultra microscopic. Later they became more complex and larger. Thru variation in the process of cell division, some cells were formed that did not split entirely apart. These, perhaps, were the

beginning of the cell colonies. Variation went on to determine which colonies should exist and which should perish. Myriads of groups were tried out. A mechanism somewhat like the following finally prevailed.

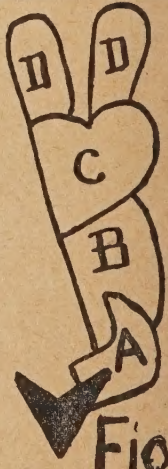
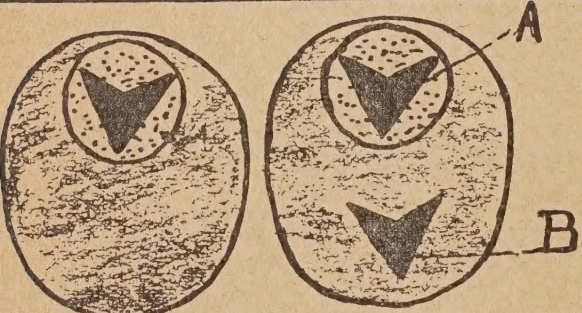
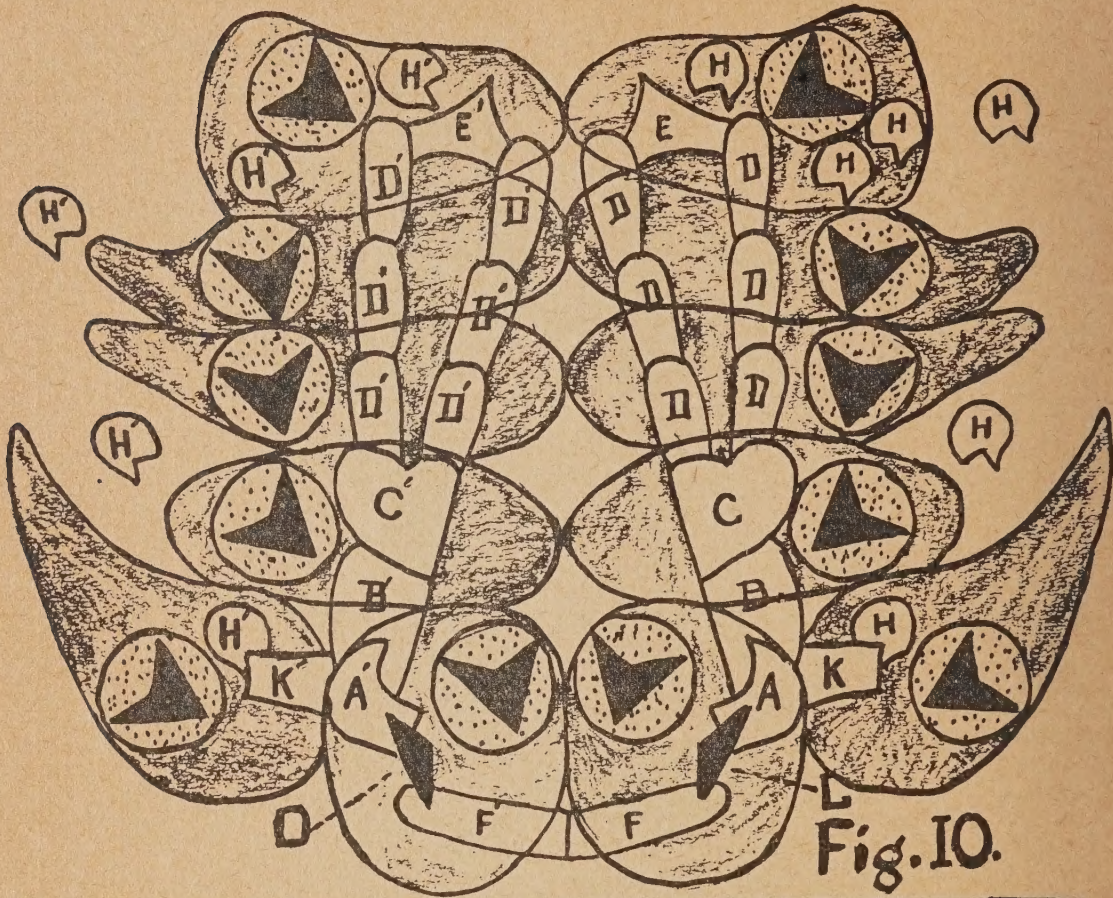


Fig. 7, shows a zygote or ovum with its hereditary molecule, the arrow shaped structure shown in black, associated with the nucleus. The nucleus is the round stippled figure within Fig. 7. Figure 8

is the same as Figure 7, except that the HEREDITARY MOLECULE has divided and each half has regenerated so that there are two new ones, one of which has passed into the cytoplasm. One of them has remained associated with the nucleus and its function is to produce new cells by division and regeneration. The other hereditary molecule, B. Fig. 8, has passed into the cytoplasm and is the controlling factor in cell differentiation and in the space arrangement of the bilateral multi-cellular organisms.

The bilateral Fig. 10 above the black line on Page 7 represents schematically a multicellular organism arising out of the ovum Fig. 8. The cells are differentiated. Associated with each nucleus is an HEREDITARY MOLECULE (the arrow-head shaped figure in black) capable of dividing and reproducing new cells. Figure 9, Page 7 shows how under certain conditions the HEREDITARY MOLECULE that has passed into the cytoplasm as mentioned above, due to selective chemical affinity, will take up a certain type of radicle A. in a given position. Radicle A, will in turn take up a certain type of radicle B, and B will only take up radicle C, and so on in sequence.

In the first cleavage of the ovum the right portion of the HEREDITARY MOLECULE B. Fig. 8 was left in cell L. Fig 10. Its left portion was left in cell O. Fig. 10. Further cell division has laid down new cells. Those portions of the HEREDITARY MOLECULE B. Fig. 8. left in cells L. and O. Fig. 10 take up radicles as illustrated in Fig. 9 and invade these new cells and by their presence in the invaded cells produce chemical changes that cause differentiation in the cells. Each cell is differentiated according to the chemical and spacial arrangement of the radicles invading it.

Note:

The above description of newly formed cells being invaded by the creeping determinate is probably not entirely descriptive of what takes place but nevertheless serves well in giving a useful mental picture in cell differentiation. In reality it is more likely that before the mother cell divides into the two daughter cells that the portions forming the two daughter cells are already organized, more or less, by the creeping determinate and that the creeping determinate remains continuous between the cells when division take place.

You will note that the chains of radicles in Fig. 10 that is chain A, B, C, and D, etc., on the right side and chain A prime, B prime, C prime, etc., on the left side that arise from the right and left halves of the HEREDITARY MOLECULE B, and left in cells L. and O. respectively, have the same form, except that the two chains are mirror-twin in arrangement, to each other. Consequently the two lateral halves of the schematic organism Fig. 10 hold mirror-twin positions to each other.

These structures, which are composed of definite chemical radicles, that are outgrowths from the HEREDITARY MOLECULE as described above and invade and organize cells into bilateral structures, we give the name THE CREEPING DETERMINATE.

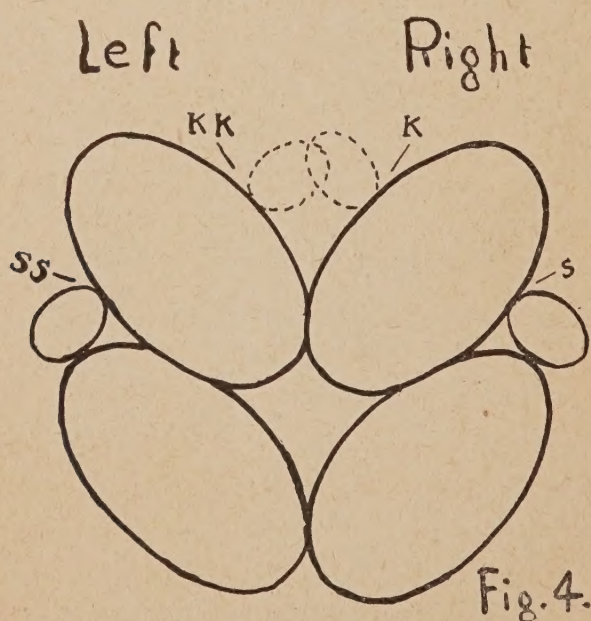
THE ORIGIN AND FUNCTION OF CERTAIN HARMONES

If one will observe the arrangement of the radicles on the right side of Fig. 10 he will find that the radicle C has attached to it two radicles of the D type. These two radicles D that are attached to C have, due to the arrangement of their fields of force, each taken up another radical D which in turn each take up another radical D. You will notice that the two chains composed of D radicles on the right side have diverged so that an opening occurs in the fields of force where radicle E can find attachment, so that the cell in which the E radicle falls is differentiated differently from the cells containing only the D radicles. The presence of the E radicle in the cell containing it causes the cell to produce chemical body H which possibly acts as a certain type of hormone. These chemical bodies H find their way into the circulation and find an attachment in the K radicle of the creeping determinate as shown in Fig. 10, and produce the type of cell that contains both K and H in the lower right hand portion of Fig. 10.

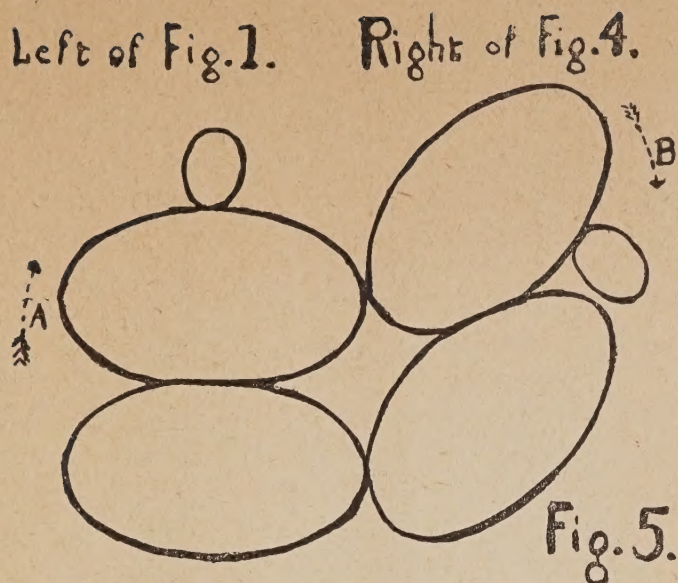
Thus thru the process of the survival of the fit, or the "cut and try method" in the billion and a half years more or less thru which the biological tree has extended many wonderful and complex organisms have evolved out of the mirror-twin molecule.

FERTILIZATION

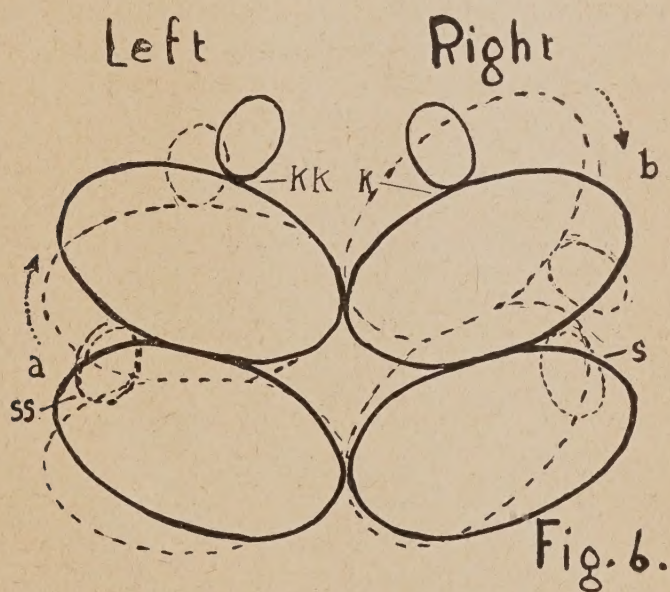
Turning now to fertilization. In this hypothesis in order to give rise to offspring that is somewhat of a mean in structure between the bodies of the two parents we must start with an HEREDITARY MOLECULE that in form is a mean between the HEREDITARY MOLECULES of the two parents. The mechanism which brings about this structure is somewhat as follows: Fig. 1. represents the arrangement of the male hereditary molecule and Fig. 4. female.



The right half of the male HEREDITARY MOLECULE joins the left hand of the female by virtue of selective chemical affinity, and gives



rise to a structure of form Fig. 5. But the fields of force in Fig. 5 are under strain. To bring about a balance the atomic groups and their fields of force of the left half are warped in the direction of arrow A. and on the right half are warped in the direction of arrow B until they



come to a balance as shown in Fig. 6. By this process you will notice that you will get an hereditary molecule in Fig. 6 that is a mean in arrangement between the male hereditary molecule Fig. 1 and the hereditary molecule, Fig. 4.

Our first paper, on the Mechanics of Heredity, given at the end of this second, was published in May 1929. It was written rather hurriedly. When it came from the press we found it so full of typographical errors and omitted explanations that we made no general distribution of it. Among the shortcomings of the first one are:

First, the theory given of the cause of selective chemical affinity is unnecessarily specific. Thru an oversight we failed to mention the repulsive and attractive forces existing between electrons, protons, atoms, and atomic groups, as conceived of in the electron theory. The paper entertained Mendeleeff's idea that selective chemical affinity is largely dependent upon the harmonious motions of bodies moving in orbits within the molecule. Our paper assumes that the force of gravity or similar force existed between the bodies moving in orbits within the molecule, so that the position of a body moving in one orbit influenced the position of a body moving in another. We chose this theory more because it lent itself better in illustrating the phenomena of fertilization than others did rather than that it was necessarily the most rational hypothesis. Further consideration, however, leads us to the belief that possibly it is fields of force associated with the atomic groups in the molecule that determines the positions of the atoms within the molecule rather than that gravity between bodies moving in orbits determines their positions. This second view, however, does not preclude the first as being rational but it is probably more in keeping with the conceptions of most students of chemistry. Therefore in perusing our first writing, if it so pleases the reader, wherever we speak of bodies moving in orbits, orbital plains, etc., he may interpret it to refer to the attractive and repulsive forces associated with atoms or atomic groups that cause a specific radicle or group to unite to protoplasm in a given position, etc.

Second, some of the references given at the close of the paper are not complete. However, they are sufficiently accurate to enable the reader to find the article referred to.

DISCUSSIONS APPLYING TO THE FIRST PAPER

The following discussions are better understood if the reader will first read the first paper which is given after Page 14 of this second article. At the top of page 17 of the first article we speak of sub-creeping determinates that are offsprings from the creeping determinate. These subcreeping determinates give rise to such structures as skin, nerves and blood vessels. It probably would be well to speak of the portion of the creeping determinate that gives the general form to the body as the **primary creeping determinate** in counter distinction to these **subcreeping determinates** which control the formation of such structures as nerves, blood vessels, skin, etc.

As suggested above these subcreeping determinates only produce their tissues when some part of the body is lacking in its normal supply. When a part lacks sufficient blood or nerve supply local chemical bodies or harmones are produced in the tissues needing the blood vessels or nerves. These chemical bodies stimulate nearby blood vessels or nerves to invade the parts. When these invading tissues become sufficient for the parts these harmones are no longer produced.

The atomic pattern of the primary creeping determinate holds somewhat the relation to the atomic pattern of these subcreeping determinates of the blood vessels and nerves as the atomic pattern of a crystal holds

to the atomic pattern of a loop of thread about which a crystal may be made to form. If one ties a loop of thread about a small crystal, for instance, one of blue vitrol, and suspends the crystal by a thread in a supersaturated solution of that salt, the crystal will continue to grow until finally the loop of thread is included within the body of the crystal. The break in the atomic pattern of the crystal due to the presence of the loop of thread it contains does not prevent the crystal growing true to the form that it would, were not the thread included within it. There is no doubt but that there are special mechanisms developed by which in certain locations the primary creeping determinate influences the character of the subcreeping determinates however.

Local conditions at times interfering with the extension of the normal nerves into a part accounts for lack of perfect mirror imaging of right and left hand finger prints as observed in certain cases in criminal identification. When unusual nerves in place of normal ones extend and supply the finger tips on one side of the body the nerve endings are laid down in abnormal pattern, therefore the finger print pattern on that side differ from those of the normal side.

It is hardly necessary to mention that the creeping determinate is more or less elastic and will stretch and retract within certain limits, in much the same way as a rubber band will without disturbing the general arrangement of the atomic pattern.

VARIATION IN THE MECHANISMS OF FERTILIZATION

Different conditions to which the various lines of descendants have been subjected have produced marked variation in the details of fertilization in these different forms. In some insects the complete phenomena possibly is not complete after the sperm and ovum unite until the second generation, or in other words, in the grandchildren. This is deducted because certain unfertilized insect eggs or ovum show a bilateral arrangement within their structure before the first cleavage of the cell takes place. Coloring matter having definite position in these bilateral structures within these unfertilized ovum has been mapped out and it is known that certain portions of this colored matter give rise to certain tissues, muscle for instance, when later it is deposited in cells after cell division. These ovum divide so as to cast one-half of the bilateral pattern into one cell in the first cleavage and the other half into the other cell. After further cell division these portions of colored matter keep definite position and give rise to certain tissues. These bilateral structures have been displaced in the ovum by mechanical means so that they do not hold their normal position. Then the ovum after cleavage will not develop bisymmetrically but muscle tissue appears in abnormal places.

Under this hypothesis the bilateral symmetry seen in the ovum is due to the HEREDITARY MOLECULE of Fig. 7. (Second paper) having passed into the cytoplasm as shown in B. Fig. 8 (Second

paper) before the fertilization takes place and it having taken up radicles as described and illustrated in Fig. 9 (Second paper) until it becomes large enough to be visible, before segmentation of the ovum takes place. In these cases the HEREDITARY MOLECULE of the ovum that has passed into the cytoplasm, that is the one that is the factor in bilateral cell differentiation: B. Fig. 8 Page 6 (Second paper) does not enter into union with the HEREDITARY MOLECULE of the sperm. Therefore the individual arising out of this ovum has only the form of the mother except insofar as chemical bodies other than the HEREDITARY MOLECULE, that are present in the sperm may modify development. However, the HEREDITARY MOLECULE of the sperm unites with the HEREDITARY MOLECULE associated with the nucleus of the ovum, the one as described and illustrated by A. Fig. 8 (Second paper) so that all cells resulting from cell division in the development of the multicellular organism contains HEREDITARY MOLECULES that in arrangement and form are a mean between those of the parents. These, of course, will give grandchildren whose bodies are a mean in arrangement between the maternal grandparents.

It has been demonstrated that environment, food, etc., in some animals has something to do with sex development. This is explained under this theory, that the various chemical radicles controlling the sex have optimal conditions under which they will form and under which they can find attachment or otherwise produce their effect upon the creeping determinate. Probably the organism can produce bodies capable of producing either male or female, structure. Then the sex that develops depends upon which chemical body has optimal conditions for its production and for its effect upon the creeping determinate. Rarely conditions are such that both male and female chemical producing bodies are formed in the individual and both produce their effects on the creeping determinate so that hermaphroditism results.

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